TABLE 6-VI-1.
MAIN MODEL OPTIONS FOR OCDCPM SIMULATIONS

OPTION	OPTION LIST	OPTION SPECIFICATION: 0 = IGNORE OPTION; 1 = USE OPTION
1	USE TERRAIN ADJUSTMENTS	1
2	DO NOT INCLUDE STACK DOWNWASH CALCULATIONS	0
3	DO NOT INCLUDE GRADUAL PLUME RISE CALCULATIONS	0
4	USE BUOYANCY INDUCED DISPERSION	1
5	READ MET DATA FROM CARDS	0 or 1
6	READ HOURLY EMISSIONS	0
7	SPECIFY SIGNIFICANT SOURCES	0
8	READ RADIAL DISTANCES TO GENERATE RECEPTORS	0
	PRINTED OUTPUT OPTIONS	
9	DELETE EMISSIONS WITH HEIGHT TABLE	1
10	DELETE MET DATA SUMMARY FOR AVG PERIOD	1
11	DELETE HOURLY CONTRIBUTIONS	1
12	DELETE MET DATA ON HOURLY CONTRIBUTIONS	1
13	DELETE CASE STUDY PRINTOUT OF PLUME TRANSPORT AND DISPERSION ON HOURLY CONTRIBUTIONS	1
14	DELETE HOURLY SUMMARY	1
15	DELETE MET DATA ON HRLY SUMMARY	1
16	DELETE CASE STUDY PRINTOUT OF PLUME TRANSPORT AND DISPERSION ON HOURLY SUMMARY	1
17	DELETE AVG-PERIOD CONTRIBUTIONS	1
18	DELETE AVERAGING PERIOD SUMMARY	1
19	DELETE AVG CONCENTRATIONS AND HI-5 TABLES	0
	OTHER CONTROL AND OUTPUT OPTIONS	
20	RUN IS PART OF A SEGMENTED RUN (Disabled)	0
21	WRITE PARTIAL CONC TO DISK OR TAPE (Disabled)	0
22	WRITE HOURLY CONC TO DISK OR TAPE	0
23	WRITE AVG-PERIOD CONC TO DISK OR TAPE (Disabled)	0
24	PUNCH AVG-PERIOD CONC ONTO CARDS (Disabled)	0
25	READ OVERWATER METEOROLOGICAL DATA	1
26	SPECIFY POLLUTANT DECAY RATE	0
27	ADJUST REFLECTION FACTOR FOR SLOPING TERRAIN	0
28	COMPLEX TERRAIN OPTION	1

TABLE 6-VI-2.

TYPICAL SURFACE ROUGHNESS LENGTHS FOR VARIOUS GROUND COVERS[a]

GROUND COVER	SURFACE ROUGHNESS LENGTHS (meters)
Water surface[b]	0.00001 - 0.004
Fallow field or low grass	0.01 - 0.03
High grass	0.03 - 0.10
Sand dunes	0.05 - 0.10
Flat rural, few trees[c]	0.003 - 0.03
Rural, rolling terrain, few trees[c]	0.01 - 0.15
Woods[c]	1.00
Suburban[c]	0.5 - 1.5
Urban[c]	1.5 - 4.0
Dense vegetation cover	1/8 of the average canopy height

[a]From Hanna, et al., 1984.

[b]Roughness length increases with increasing wind speed.

[c]Roughness length increases for taller or more closely spaced obstacles to wind flow, or for higher terrain obstacles.

The following wind profile exponents (PL) should be used:

0.10, 0.15, 0.20, 0.25, 0.30, 0.30

C. Point Source Description Information

The following inputs are required for each source of emissions modeled: source location (Universal Transverse Mercator (UTM) coordinates), pollutant emission rate, height of tallest building at or near stack location, height of stack top above reference level, stack gas temperature, stack inside diameter, stack gas exit velocity, deviation of stack angle from the vertical, and the source "ground level" elevation. All of these parameters must be reviewed by the District engineering staff prior to submission of modeling results.

Maximum hourly emission rates are to be used in modeling all averaging periods less than or equal to 24 hours. Annual average emission rates are to be used in modeling all annual average concentrations. Emission rates are described more fully in Section 6.II.C. of this manual.

The height of the building or obstacle at or near the stack location that exerts primary influence on building downwash effects must be specified. In many cases, this will be the building to which the stack is attached. However, if a nearby building or other solid structure has larger dimensions than the building to which the stack is attached, the Good Engineering Practice (GEP) stack height should be calculated for each building (refer to Rule 205.C.1.a.16 for GEP stack height definition), and the height of the building with the higher GEP stack height should be used for this parameter. For an offshore platform, this parameter will be the height of the tallest solid structure or section on the top deck of the platform, specified as the height above the source "ground level." The source "ground level" is defined below.

The stack height is specified as the height above the source "ground level." For onshore sources, the source "ground level" is the local ground elevation. For simple offshore sources in contact with the water (crew and supply boats, tankers, construction barges, etc.), the water level is the source "ground level" (ELP(NPT)=0.). For more complex offshore sources that extend above the water on stilts or legs, such as drilling or production platforms, the source "ground level" is the base structure above which the stack extends. For instance, the source "ground level" for a multideck platform would be the height above the water level of the lowest deck. The definition of stack height for a non-vertical stack is discussed below.

The deviation of the stack angle from the vertical is specified in degrees. A vertical stack would have a stack angle deviation of Ø.Ø, a horizontal stack would show a deviation of 9Ø.Ø. Other angles are possible. For a non-vertical stack, the stack height is not defined as the physical length of the stack, but rather is the height of the center of the stack top above the source "ground level."

The final parameter required in this section is the elevation of the source "ground level" defined above. For onshore sources, this is the ground elevation above mean sea level. For platforms, this is the elevation above mean sea level of the lowest platform deck. The elevation of the source "ground level" is to be specified in feet or meters with the appropriate multiplier indicated for variable CELM in card type 4. For simple offshore sources in contact with the water (i.e. crew and supply boats, tankers, construction barges, etc.) the source "ground level" elevation (ELP(NPT)) will be zero (Ø.).

As an example of the interrelationship of the parameters described above, consider an offshore platform with three decks, at 15, 25, and 35 meters above the water surface. The source "ground level" would be the elevation of the lowest deck, 15 meters. All stack heights would be defined as heights above the lowest deck. For instance, a diesel source with a vertical stack that was two (2) meters tall and was located on the second deck would have a value of (25 - 15) + 2 = 12 meters for the stack height. A flare boom with a length of 2Ø meters that extended from the top deck at a 45 degree angle would have a stack height of (35 - 15) + (sin 45 degrees x 2Ø) = 34.14 meters. The height of the obstacle influencing downwash would be the height of the largest solid structure extending above the upper deck. For example, a three (3) meter high enclosure on the upper deck would be specified as a height above the source "ground level" of 15 meters, that is (35 - 15) + 3 = 23 meters.

D. Meteorology

As the OCDCPM model is to be applied to offshore sources and coastal point sources associated with offshore facilities, both overland and overwater meteorology are required inputs. In order for OCDCPM to consider overland and overwater meteorological data inputs, both IOPT(5) and IOPT(25) must be set equal to 1.

Default meteorological data, which can be generated internally by OCDCPM when measured data are not available, are not to be used. All meteorological inputs to OCDCPM must be obtained externally either as data actually measured and accepted by the District, or as specified values listed in Section D.1.c. For every hour contained in the simultaneous overland and overwater data sets, all parameters must be specified with a value. This will result in OCDCPM not calculating default meteorological data or applying the climatological values of data provided by the user.

Overland and overwater preconstruction monitoring data sets to be used as input to OCDCPM, must be of at least one year duration with a minimum 90 percent approved data capture rate. The following procedure may be used to "fill in" the data set to 100% capture. Generally, short periods of one to six hours may be interpolated, with District approval, from data at the same site. Longer periods of missing data may be filled in with actual data from another site(s) which the District has approved as representative. Data from offshore sites can not be used to substitute for missing data from onshore sites, although with District approval, data from onshore sites may be substituted for data from an offshore site if no other representative offshore site is available.

In all cases, overwater turbulent intensities (IYW, IZW) will be the reasonable worst case values presented in Table 6-IV-4.

It must be emphasized that the requirement to utilize all or part of the reasonable worst-case meteorological data as prescribed above does not imply that the applicant is not required to collect preconstruction monitoring data. Applicants will be required to collect and have validated by the District at least one year of air quality and meteorological data prior to the District considering the project application as complete. The reasonable worst-case meteorological data, are to be used in lieu of actual data when the actual data are missing for extended periods, when the data have not been collected according to the Districts monitoring protocol, or if the data are deemed unacceptable by the District. Analyses outside the District permitting process which may not require preconstruction monitoring of meteorological data must utilize the reasonable worst-case values.

1. Meteorological Data Set Considerations

This section presents the meteorological data sets which can be utilized by OCDCPM. Meteorological input parameters required by OCDCPM to satisfy District requirements are discussed with respect to the hierarchy and manner in which these data are to be input to the model.

a. Overland Meteorology

Overland meteorological parameters required by OCDCPM are wind speed, wind direction, temperature, stability class, and mixing height. At a minimum, hourly averaged wind speed, wind direction, stability class and temperature are to be obtained from the District-approved preconstruction monitoring program for the proposed project (SBAPCD, 1985). A discussion of the overland meteorological parameters and the hierarchy of their use is as follows:

i. Overland wind direction

- use measured overland values, if available.
- If measured overland values are not available, the applicant must use reasonable worst-case meteorology (Section D.l.c.) for all parameters of both the overland and additional meteorological data sets.

ii. Overland wind speed

- use measured overland values, if available.

Calm periods in the overland data set are to be handled as follows:

- All wind speeds less than 1 m/sec must be converted to 1 m/sec prior to input to the OCDCPM model.

- The CRSTER pre-processor, which may be utilized, deals with calm winds (hourly mean wind speed approaching Ø) in the following manner:

  - Wind speeds less than 1 m/sec are set equal to 1 m/sec.

  - The wind direction is set equal to the value for the last non-calm hour.

- If measured overland values are not available, the applicant must use reasonable worst-case meteorology (Section D.1.c.) for all parameters of both the overland and additional meteorological data sets.

iii. Overland air temperature

- Use measured overland values, if available.

- If measured values are not available, use the value specified in Section D.1.c. for all hours.

iv. Overland stability class

- Use values calculated per District procedures (SBAPCD, 1983; USEPA, 1986) if the data used to calculate stability class are available.

- If calculated values are not available, the applicant must use reasonable worst-case meteorology (Section D.1.c.) for all parameters of both the overland and additional meteorological data sets.

v. Overland mixing height

Twice daily mixing heights are available from Pt. Mugu and Vandenberg. If unavailable, hourly mixing heights can be estimated from Holzworth (1972).

iii. Overwater mixing height

- Use measured overwater values, if available, and specify JOPT(3)=1.

- If overwater values are not available and an actual onshore data set is being utilized, use a value of 250 meters.

- If reasonable worst-case meteorological data are to be used, use the range of values specified in Section D.1.c. and specify JOPT(3)=1.

iv. Overwater relative humidity

- Use measured overwater values, if available, and specify:

  JOPT(4)=1 if relative humidity is provided;
  JOPT(4)=2 if wet bulb temperature is provided;
  JOPT(4)=3 if dew point temperature is provided.

- If overwater values are not available, use the value specified in Section D.1.c. for all hours and specify JOPT(4)=1.

v. Overwater air temperature

- Use measured overwater values, if available, and specify JOPT(5)=1.

- If overwater values are not available, use the value specified in Section D.1.c. for all hours and specify JOPT(5)=1.

vi. Water surface temperature

- Use measured overwater values, if available, and specify:

  JOPT(6)=1 if water surface is provided;
  JOPT(6)=2 if air minus water surface temperature is provided.

- If overwater values are not available, use the value specified in Section D.1.c. for all hours and specify JOPT(6)=2.

ii. Overwater wind speed

- Use measured overwater values if available and specify JOPT(2)=1.

- If overwater values are not available, incorporate overland values from District-approved onshore site directly into the additional meteorological data set and specify JOPT(2)=1. This will result in not allowing OCDCPM to calculate a default offshore wind speed for the overland data.

- If overwater and overland values are not available, use value specified in Section D.1.c. for all hours and specify JOPT(2)=1. If both overwater and overland wind directions are not available, the applicant must use reasonable worst-case meteorology (Section D.1.c.) for all parameters of both the additional meteorological data and overland data sets.

iii. Overwater mixing height

- Use measured overwater values, if available, and specify JOPT(3)=1.

- If overwater values are not available and an actual onshore data set is being utilized, use a value of 250 meters.

- If reasonable worst-case meteorological data are to be used, use the range of values specified in Section D.1.c. and specify JOPT(3)=1.

iv. Overwater relative humidity

- Use measured overwater values, if available, and specify:

  JOPT(4)=1 if relative humidity is provided;
  JOPT(4)=2 if wet bulb temperature is provided;
  JOPT(4)=3 if dew point temperature is provided.

- If overwater values are not available, use the value specified in Section D.1.c. for all hours and specify JOPT(4)=1.

v. Overwater air temperature

- Use measured overwater values, if available, and specify JOPT(5)=1.

- If overwater values are not available, use the value specified in Section D.1.c. for all hours and specify JOPT(5)=1.

vi. Water surface temperature

- Use measured overwater values, if available, and specify:

  JOPT(6)=1 if water surface is provided;
  JOPT(6)=2 if air minus water surface temperature is provided.

- If overwater values are not available, use the value specified in Section D.1.c. for all hours and specify JOPT(6)=2.

vii. Overwater wind direction shear

- In all instances, a value of -999.9 (indicating missing data) is to be used for all hours. JOPT(7) is to be specified as 0.

viii. Overwater horizontal turbulence intensity

- A value of 0.045 is to be used for all hours, in all instances. Actual measurements of this parameter will not be approved for use by the District until further studies have been conducted to examine the OCDCPM model parameterization of plume dimensions from turbulence intensities. JOPT(8) is to be specified as 1 in all situations. This will result in not allowing OCDCPM to calculate default values of overwater horizontal turbulence intensities.

ix. Overwater vertical turbulence intensity

- A value of 0.020 is to be used for all hours, in all instances. Actual measurements of this parameter will not be approved for use by the District until further studies have been conducted to examine the OCDCPM model parameterization of plume dimensions from turbulence intensities. JOPT(9) is to be specified as 1 in all situations. This will result in not allowing OCDCPM to calculate default values of overwater vertical turbulence intensities.

x. Overland turbulence intensities

- Overland horizontal and vertical turbulence intensities (IYL and IZL, respectively) are not to be used as direct input to OCDCPM. Utilize a value of -999.9 for this parameter which indicates that overland turbulence intensities will not be used. Specify JOPT(10) as 0 in all situations. Overland horizontal/vertical turbulence intensities can be used to calculate stability classifications per District procedures and used as input in the overland data set.

xi. Overwater vertical potential temperature gradient

- In all instances, the value specified in Section D.1.c. is to be used for all hours. JOPT(11) is to be specified as 1.

Table 6-VI-3 summarizes the additional meteorological data options which can be used in the OCDCPM simulations.

The height of the overwater anemometer and air temperature sensor must also be provided. Specify the actual height of these instruments in meters above the water level or utilize a value of 10 meters if these parameters are not measured (reasonable worst-case meteorology is being utilized).

c. Reasonable Worst-Case Meteorological Data

The adequacy of any overwater or overland meteorological data set will be determined by District staff on a case-by-case basis. The applicant should review proposed meteorological data with the District prior to commencement of OCDCPM modeling. If certain data requirements listed in Sections VI.D.1.a. and VI.D.1.b. are not met, the analysis must utilize reasonable worst-case meteorology as input to OCDCPM. The reasonable worst-case data set is presented in Table 6-VI-4.

If the use of reasonable worst case meteorology is required, then the user is to prepare an hourly data set as specified in Table 6-VI-4 of this manual, including all wind directions likely to produce maximum impacts from the proposed project on coastal terrain. A variety of mixing heights should be examined in initial model runs to determine the height that will result in the highest modeled impacts. Equivalent overland and overwater mixing heights from 100 to 300 meters, in 50 meter increments, should be assessed for each wind direction modeled. The District has created an interactive FORTRAN program that will assemble an appropriate data set when reasonable worst-case meteorological data are required for all parameters. Potential users may contact the District for a copy of the program.

TABLE 6-VI-3.
ADDITIONAL METEOROLOGICAL DATA OPTIONS FOR OCDCPM SIMULATIONS

OPTION	OPTION LIST	OPTION SPECIFICATION*
1	OVERWATER WIND DIRECTION PROVIDED	0 or 1
2	OVERWATER WIND SPEED PROVIDED	1
3	OVERWATER MIXING HEIGHT PROVIDED	1
4	OVERWATER HUMIDITY SPECIFICATION	1,2 or 3
5	OVERWATER AIR TEMPERATURE PROVIDED	1
6	WATER SURFACE TEMPERATURE SPECIFICATION	1 or 2
7	OVERWATER WIND DIRECTION SHEAR PROVIDED	0
8	OVERWATER HORIZONTAL TURBULENCE INTENSITY PROVIDED	1
9	OVERWATER VERTICAL TURBULENCE INTENSITY PROVIDED	1
10	OVERLAND TURBULENCE INTENSITY PROVIDED	0
11	OVERWATER POTENTIAL TEMPERATURE GRADIENT PROVIDED	1

* Unless otherwise specified, 1 = provided, 0 = not provided, or do not use.

TABLE 6-IV-4. REASONABLE WORST-CASE METEOROLOGICAL DATA SET FOR OCDCPM SIMULATIONS

PARAMETER	INPUT VALUES (S)
Overwater	
Wind Direction (WD)	Applicable sector of wind directions in one degree (1°) increments
Wind Speed (WS)	1.0 m/sec
Mixing Height (HLW)	Height to result in highest modeled impacts or 100 to 300 m in 50 m increments
Relative Humidity (WHUM)	90 percent
Air Temperature (WTA)	290° K
Air to Sea Surface (WTS) Temperature Difference	+2.0° K
Wind Direction Shear (WDSHR)	-999.9
Overwater Horizontal (IYW) Turbulence Intensity	0.045
Overwater Vertical (IZW) Turbulence Intensity	0.020
Overland Horizontal (IYL) Turbulence Intensity	-999.9
Overland Vertical (IZL) Turbulence Intensity	-999.9
Vertical Temperature Gradient (WDTHDZ)	0.05°k/m
Overland	
Wind Direction (WD)	Same directions as used for overwater data set
Wind Speed (WS)	1.0 m/sec
Mixing Height (HLH)	Same mixing heights as used for overwater data set
Stability Class (KST)	6 (Stability Class F)
Air Temperature (TEMP)	290° K

When utilizing reasonable worst-case meteorological data, maximum modeled concentrations will be representative of one-hour averaging periods only. Table 6-VI-5 lists multiplying factors which are to be used to convert the maximum one-hour modeled concentrations to concentrations representative of longer averaging periods.

TABLE 6-VI-5.
FACTORS TO CONVERT ONE-HOUR MODELED CONCENTRATIONS TO LONGER AVERAGING PERIODS.

Modeling Result Averaging Period	Averaging Period	Multiplying Factor
1-hr	3-hr	Ø.9Ø
1-hr	8-hr	Ø.7Ø
1-hr	24-hr	Ø.4Ø
1-hr	Annual	Ø.1Ø

d. Overwater Climatological Values

Card type 14 of the OCDCPM input file requires monthly average values of overwater mixing height, overwater relative humidity, overwater air temperature and overwater air minus water temperature. However, in all cases, hourly values of these parameters will be specified for use in the model, either with actual overwater measurements or with the reasonable worst-case values listed in Section D.l.c. Therefore, the climatological values input to the model will not be utilized. As the user must provide the climatological data in order to keep the input records OCDCPM is reading in proper order, the following values are suggested for input:

i. Climatological values of overwater mixing height by month: 12*25Ø.

ii. Climatological values of overwater relative humidity by month: 12*9Ø.

iii. Climatological values of overwater air temperature by month: 12*29Ø.

iv. Climatological values of overwater air minus water temperatures by month: 12*2.Ø.

E. Receptor Grid Spacing

Receptor points shall be placed as follows:

a. At 250 meter intervals on a cartesian grid. Receptors for offshore source simulations should begin at the shoreline and continue as far inland as necessary to cover the area(s) of maximum impact.

b. At specific discrete points to ensure that maximum potential impact is modeled (for example, on facility boundary line or on sub-grid size terrain features). The receptor grid should be large enough in extent to cover region(s) of significant impact(s).

c. Receptors shall not be placed inside the applicant's facility boundaries. Receptors are to be placed starting at discrete points along the facility boundary line or along an arc 100 meters away from the nearest source(s), depending on which distance is greater from the source in question.

d. Receptor elevations are to be obtained from 7.5 minute USGS or more detailed topographic maps.

OCDCPM also allows two additional parameters to be entered for each receptor location; the local slope and the slope base elevation. These values should be omitted or entered as zero (0), which will cause the model to compute the terrain slopes from elevation data and shoreline geometry for use in the OCD computation. These parameters are not used in the COMPLEX I/MPTER algorithms and will not be utilized if entered.

Since wind directions are set by the user in the reasonable worst-case data set, the user should take care to ensure that receptors are placed at all locations likely to produce maximum impacts due to project emissions sources. If the emissions are all produced from a single source, or a tight cluster of sources, receptors should be placed at 100 meter intervals on 1 degree radials centered on the source or source cluster. If sources are more widely spaced, a cartesian grid of receptors will be necessary to calculate maximum impacts. This cartesian grid should comply with the requirements outlined in Section 6.VI.B.4. of this manual. In no case shall the cartesian grid receptors be more widely spaced than every 250 meters. At District discretion, a smaller receptor spacing may be required to ensure that maximum impacts are calculated. All receptor sets must be approved by District staff prior to initiation of modeling.

F. Shoreline Geometry

OCDCPM requires specification of the location of the shoreline relative to source and receptor locations. All receptors and sources involved in a given simulation must be within the area specified by the shoreline geometry grid. This may require the user to break simulations down into several shorter runs for particular subsets of sources or receptors since the number of map grid cells that can be specified for a single OCDCPM simulation is limited.

The maximum grid cell length (horizontal or vertical) that should be specified is one-half kilometer. Horizontal and vertical grid cell lengths do not need to be the same as long as each is less than or equal to one-half kilometer. It may be necessary to adjust the designation (as water or land) of individual grid cells to ensure that shoreline receptors are located in a cell specified as "land".

The minimum along wind width for a land or water body to be considered significant should be set equal to the smaller of the horizontal and vertical grid cell lengths.

G. Background Air Quality

Background air quality concentrations should be determined in accordance with the procedures and specifications outlined in Section 6.II.D. and 6.II.E. of this manual.

H. Modifications

In order to assess cumulative air quality impacts from different source types, modeled pollutant concentrations from point sources and non-point sources which impact the same receptor during a given hour are to be summed together. This will require the use of a post-processor program and may require modifications to model code to output concentrations in a format acceptable to the post-processor. The District can provide a FORTRAN post-processor program that will perform this function, along with versions of OCDCPM and ISCST that will work with the post-processor. Please contact District staff for further information.

VII. References

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DEVELOPMENT OF REASONABLE WORST-CASE VALUES OF OVERWATER HORIZONTAL TURBULENCE INTENSITIES (IYW)

1. Introduction

The main purpose of this analysis is to assess the overwater dispersion parameters in the OCDCPM model and to document the development of the reasonable worst-case turbulence intensities used to simulate plume dimensions observed offshore Santa Barbara County. The development of the reasonable worst-case turbulence intensity values used in the Santa Barbara County APCD OCDCPM modeling protocol was based on several basic premises. These premises are summarized as follows:

a. Plume dimensions calculated by OCD (both horizontal and vertical) should reflect actual worst-case plume dimensions observed offshore. Hourly averaged plume concentrations indicative of P-G stability class F or more stable (G) were measured during the 1980 SANBOX study in the Santa Barbara Channel. OCD-calculated plume dimensions should emulate these observed values. A discussion of the observed plume dimensions during the SANBOX study is contained in the analysis section (Section 2) of this document. Also, the Santa Barbara County APCD comments to OAQPS regarding the proposed revisions to the air quality modeling guidelines discuss this subject in greater detail.

b. Plumes observed offshore should reflect less dispersion than dispersion calculated by the EPA-preferred onshore model, MPTER (comparing non-complex terrain models). The 1980 SANBOX study observed plume dimensions smaller than those calculated by MPTER σ_y and σ_z values for P-G stability class F. The OCD model using default dispersion parameters results in much greater dispersion than that calculated by the MPTER model.

c. It is the product of turbulence intensity, distance from source to receptor and the non-dimensional function relating turbulence intensities to plume dimensions which must be considered, not just the value of the turbulence intensity itself. The argument that certain values of turbulence intensities are too conservative is not valid without appropriate consideration of the other terms contributing to the plume dimension calculation. The "bottom line" is what should be considered, not an individual component which contributes to the "bottom line."

The analysis section of this document presents a comparison of MPTER and OCD dispersion calculations. The dispersion calculations are used to match $\sigma_y\sigma_z$ products between OCD and MPTER for P-G stability class F. From the matching of $\sigma_y\sigma_z$ products between the two models, a value of OCD σ_y is calculated. A value of overwater horizontal turbulence intensity is then calculated based on the OCDCPM formulation which relates turbulence intensity to σ_y. Also, a comparison of modeled results between OCDCPM and CPX2APCD (COMPLEX-II with overwater dispersion corrections) is discussed in the analysis section.

2. Analysis

a. Rationale for Developing Turbulence Intensity Values Which Result in Plume Dimensions Equivalent to P-G Stability Class F Dispersion

The OCD model contains many of the features of the EPA MPTER model, and was based in large part on the formulations contained in MPTER. MPTER is the EPA guideline model for assessing onshore impacts in areas of level terrain. The MPTER model uses algorithms to emulate P-G stability class dispersion, which ranges from "A" (unstable) to "F" (very stable). Using EPA-approved methods to calculate P-G stability classes for input into MPTER and other EPA models, it is generally observed that there is a large number of P-G stability class F conditions with low wind speeds included in any data set used for onshore modeling analyses. The percentage of P-G stability class F conditions generally averages about 30 percent of the total hours in an annual data set.

There is general agreement that offshore dispersion is more restrictive than onshore dispersion. Thus, it is reasonable to require that plume dimensions offshore should be less than or equal to those used in onshore modeling analyses. The OCD model in the default mode calculates much larger plume dimensions, and therefore smaller pollutant concentrations, than does MPTER. In order to be consistent with plume dimensions used in onshore modeling, turbulence intensity inputs into OCD and OCDCPM should be chosen to emulate P-G stability class F conditions. This would ensure that offshore modeling would use plume dimensions as restrictive, not more restrictive, than those commonly used onshore.

Further evidence that P-G stability class F conditions are a reasonable assumption for offshore dispersion in the Santa Barbara region can be found in the analysis of the 1980 Santa Barbara Oxidant (SANBOX) study (Smith et al., 1983). During the SANBOX study, tracer gas (SF_6) was released on six occasions to study plume transport and diffusion in the Santa Barbara Channel. During each of the six tracer release days, hourly values of tracer gas concentrations were collected at specific offshore and onshore locations and compared to Xu/Q values to estimate pollutant diffusion in terms of P-G stability categories.

The hourly averaged samples demonstrated that dispersion offshore Santa Barbara was consistent with the P-G stability class methodology. Hourly averaged samples revealed dispersion to range from P-G stability class C to G depending on whether the flow was categorized as organized or as light and meandering. The light and meandering winds produced hourly tracer sample concentrations corresponding to P-G stability classes C through E, while the more organized flows produced hourly tracer sample concentrations corresponding to P-G stability classes E through G. The computations used to obtain the *Xu/Q* values from which the the stability values were derived are the same as those included in MPTER. Refer to Figure 1 for a summary of *Xu/Q* values as they relate to distance and stability class for the 17 September 1980 SANBOX release. Similar figures for the five other tracer releases can be found in (Smith et al., 1983).

The SANBOX comparison of plume concentrations to P-G stability classes did not consider mixing depths (equation 3.5 Turner's Workbook (Turner, 1970)) However, consideration of mixing depths in the estimates of hourly P-G stability classes still results in observed hourly concentrations which would correspond to P-G stability class F. Figure 2 illustrates the change in P-G stability class determination when mixing depth is considered. It is observed that for stable cases (P-G stability class F), mixing depth is not a factor in stability class determination until downwind travel distances exceed approximately 70 kilometers. Thus, the idea that P-G stability classes are appropriate for estimating hourly averaged offshore pollutant concentrations remains valid even if mixing depth is considered.

It should also be noted that the comparison of monitored tracer values to the *Xu/Q* curves is not a conservative method of estimating P-G stability class. The chance of an individual monitor in the network measuring the plume centerline concentration is very remote. The P-G stability class determinations were based on *Xu/Q* curves which assume the plume concentration (*X*) is at plume centerline. Therefore, it is probable that many of the P-G stability class determinations made as a result of the SANBOX study were in reality more stable (less dispersive) than could be determined by the SANBOX sampling network.

Based on the determination that P-G stability class F is a realistic measure of offshore plume dimensions, an exercise to match $\sigma_y \sigma_z$ products between OCD and MPTER was conducted to determine appropriate values of OCD turbulence parameters. The following section presents the algorithms used in OCD and MPTER to calculate plume dimensions. From this information, a value of overwater horizontal turbulence intensity is calculated which results in the matching of OCD and MPTER $\sigma_y \sigma_z$ values for P-G stability class F conditions.

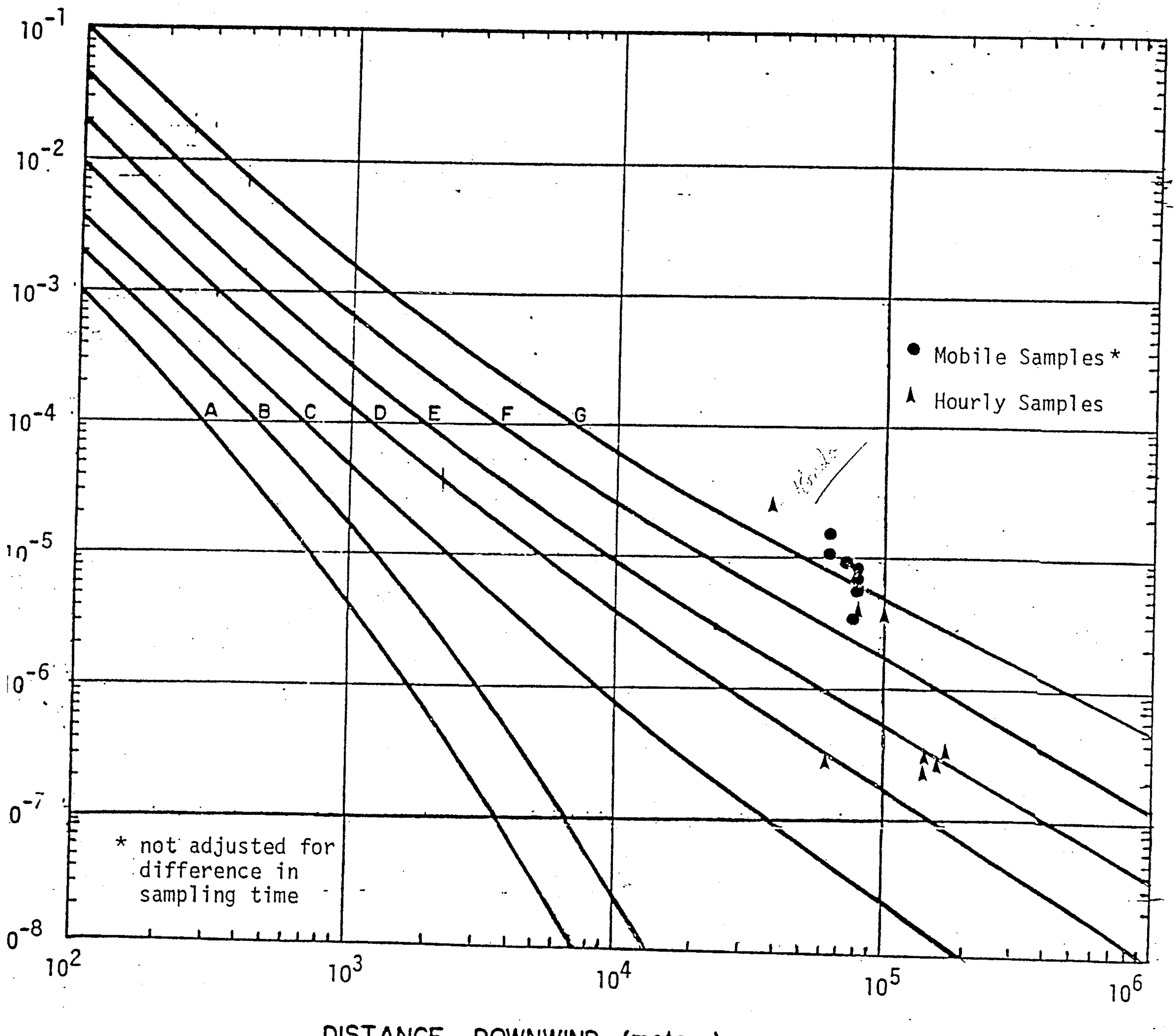

Fig. 4.2.15 XU/Q VALUES - Test 1
September 17,1980

Figure 1

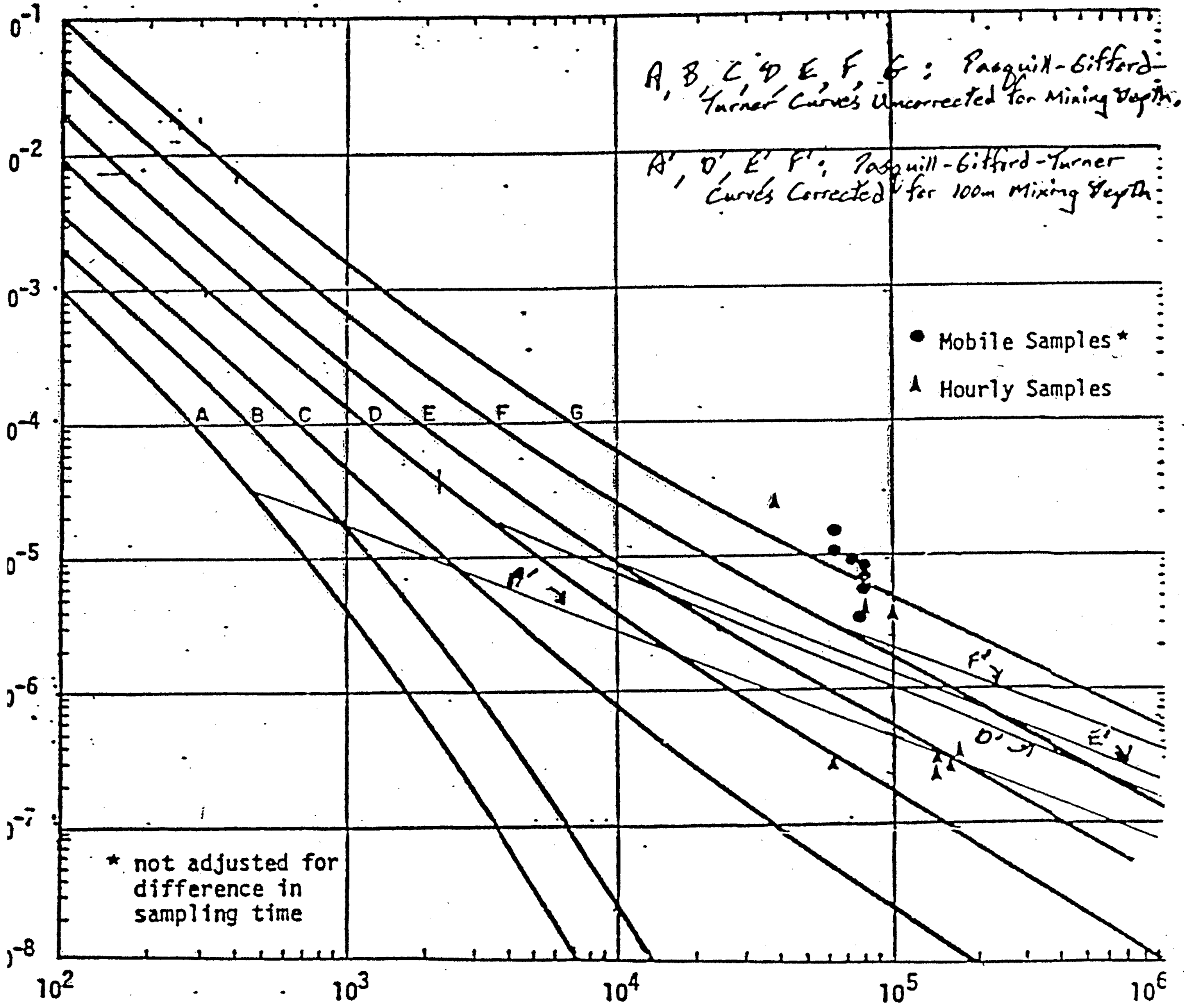

Fig. 4.2.15 XU/Q VALUES ~ Test 1
September 17,1980

SANBOX Experiment (Smith et al., 1985)

Figure 2

In OCD and OCDCPM;

$$\sigma_y^2 = \sigma_{yt}^2 + \sigma_{yb}^2 + \sigma_{ys}^2 + \sigma_{yo}^2$$

$$\sigma_z^2 = \sigma_{zt}^2 + \sigma_{zb}^2 + \sigma_{zo}^2$$

where;

σ_{yt}, σ_{zt} represent components due to turbulence

σ_{yb}, σ_{zb} represent buoyant plume enhancement components

σ_{ys} represents wind direction shear component (no contribution to the vertical component).

σ_{yo}, σ_{zo} represent structure downwash components.

Further;

$$\sigma_{yt} = i_y * x * S_y(x)$$

where;

x = distance from source to receptor if receptor is located between shoreline and where the plume enters the TIBL, else x is the distance from source to where the plume enters the TIBL

i_y = IYW = overwater horizontal turbulence intensity

= $\sigma_v/UPL = \sigma_\theta \approx \tan \sigma_\theta$ (for small angles only)

UPL = wind speed at stack height

σ_v = standard deviation of horizontal wind speed fluctuations

σ_θ = standard deviation of horizontal wind direction fluctuations

$S_y(x)$ = non-dimensional function which relates overwater horizontal turbulence intensity to horizontal plume dimension

$= (1 + 10^{-4}x)^{-.5}; \; x \leq 10^4 m$

for $x > 10^4$m, assume $x = 10^4$m and $S_y(x)$ is equal to 0.707 for all distances greater than or equal to 10^4m.

$\sigma_{zt} = i_z * x * S_z(x)$

x = distance from source to receptor if receptor is located between shoreline and where the plume enters the TIBL, else x is the distance from source to where the plume enters the TIBL

i_z = overwater vertical turbulence intensity

$= \sigma_w/UPL = \sigma_\phi \approx \tan \sigma_\phi$ (for small angles only)

σ_w = standard deviation of vertical wind speed fluctuations

σ_ϕ = standard deviation of vertical wind direction fluctuations

$S_z(x)$ is calculated as follows:

P-G KST	$S_z(x)$
A,B	1.0
C	$(1 + 0.0002X)^{-.5}$
D	$(1 + 0.0\ 15X)^{-.5}$
E,F	$(1 + 0.003X)^{-1.0}$
G	$(1 + S^{.5}X/(0.32 * UPL))^{-.5}$

P-G stability class G is implemented when the value of the overwater vertical temperature gradient is greater than or equal to 0.05 °C/m.

$$s = \frac{g}{\Theta}\frac{\delta\Theta}{\delta z}$$

g = acceleration due to gravity (9.81 ms^{-2})

Θ = potential temperature (°K); the temperature a parcel of air would have if it were brought dry adiabatically from its existing height (pressure) to a reference pressure of 1000 mb.

$\frac{\delta\Theta}{\delta z}$ = overwater vertical potential temperature gradient (WDTHDZ)

$$\sigma_{yb}^2 = \sigma_{zb}^2 = \frac{(\delta h)^2}{10}$$

δh = plume rise in meters

$= 2.6(F/us)^{1/3}$; usual calculation as buoyancy plume rise usually dominates

$F = gV_f/\Pi(1 - T_a/T_s)$

V_f = volumetric flow rate (m^3s^{-1})

$= \Pi r_s^2 V_s$

u = mean wind speed at anemometer height

V_s = stack exit velocity (ms^{-1})

r_s = stack radius (m)

T_a = ambient air temperature (°K)

T_s = stack gas temperature (°K)

$\sigma_{ys}^2 = 0.03(\delta WD)^2 x^2$

δWD = wind direction shear in radians

σ_{yo} and σ_{zo} are calculated as follows:

HB = height of building or other source (in meters) to which the stack is attached (SOURCE(4,J))
COMPON = stack deviation angle from vertical
DELHM = momentum plume rise (m) (PTR01850)

```
EFFHT = THT + DELHM * COMPON
   THT = physical stack height (m) (SOURCE (5,J))
   COMPON = COS(SOURCE(9,J)/57.29578)
   57.2598 = 180./Π
A = AMAX1(1.0,ABS(EFFHT/HB))
```

With this background, the building downwash effects are calculated in OCD and OCDCPM as follows:

IF(A.LT.1.2) both σ_y and σ_z are modified
IF(A.GE.1.2.AND.A.LT.3.0) only σ_z is modified
IF(A.GE.3.0) neither σ_y or σ_z are modified

```
IF(A.LT.1.2) THEN
   σyo = 0.79788 * HB/2.0 * (6.0 - 5.0*A)
   σzo = 0.79788 * HB/2.0 * (3.0 - A)
ELSEIF(A.GE.1.2.AND.A.LT.3.0) THEN
   σzo = 0.79788 * HB/2.0 * (3.0 - A)
ENDIF
```

---

3. MPTER

The following information applies only to P-G stability class F:

$\sigma_y^2 = \sigma_{yt}^2 + \sigma_{yb}^2$

$\sigma_z^2 = \sigma_{zt}^2 + \sigma_{zb}^2$

σ_{yt} is calculated in the following manner in MPTER:

$TH = (4.1667 - 0.36191 * ALOG(XY))/57.2958$

XY = distance from source to receptor in km.
$ALOG = ln$

$\sigma_{yt} = 465.116 * XY * SIN(TH)/COS(TH)$

$465.116 = 1000.(m/km)/2.15$

σ_{zt} is calculated in the following manner:

```
REAL XF(9),AF(10),BF(10)
DATA XF/60.,30.,15.,7.,3.,2.,1.,0.7,0.2/
DATA AF/34.219,27.074,22.651,17.386,16.187,14.283,13.953
*        13.953,14.457,15.209/
DATA BF/0.21716,0.27436,0.32681,0.41507,0.46490,.054503
*        0.63227,0.68465,0.78407,0.81558/

  DO ID = 1,9
       IF(X.GE.XF(ID)) GOTO 160
  ENDDO
  ID = 10
160  σzt = AF(ID) * X**BF(ID)
  IF (σzt.GT.5000.) σzt = 5000.
```

X = distance from source to receptor in km

For example: P-G KST F; x = 2000m = 2 km

Per the above do loop, ID = 6
AF(6) = 14.823
BF(6) = 0.54503

$\sigma_{zt} = 14.823 * 2.**0.54503 = 21.6m$

$$\sigma_{zb}^2 = \sigma_{yb}^2 = \frac{(\delta h)^2}{(3.5)^2} = \frac{(\delta h)^2}{12.25}$$

The second step in the analysis was to match $\sigma_y\sigma_z$ products calculated by OCD and MPTER for reasonable worst-case conditions. The matching of $\sigma_y\sigma_z$ products is all that is necessary as the other terms in the Gaussian distribution equations for the two models are equivalent and drop out. Based on the above algorithms, $\sigma_y\sigma_z$ product calculations were made for source to receptor distances of 1000, 2000, 3000, 4000 and 5000 meters. From the matching of the $\sigma_y\sigma_z$ products, a value of *IYW* can be determined for each source to receptor distance analyzed. The average of the *IYW* value needed to result in a match of $\sigma_y\sigma_z$ values was then taken and used as the reasonable worst-case value of overwater horizontal turbulence intensity input into OCDCPM.

The analysis to match $\sigma_y\sigma_z$ products between OCD and MPTER contained several assumptions. The assumptions used are as follows:

1. Buoyancy-induced dispersion (IOPT(4).EQ.1) is employed in both MPTER and OCD.

2. The hypothetical source(s) considered in the analysis were assumed to have a 75m buoyancy plume rise (typical for a tanker at a marine terminal). The buoyancy plume rise is used to calculate buoyancy contributions to total σ_y and σ_z.

3. The overwater vertical potential temperature gradient (WDTHDZ) was assumed to be 0.05 °C/m. This forces the value of *IZW* to be 0.02 and the $S_z(x)$ term relating *IZW* to σ_{zt} to be calculated using P-G stability class G methodology.

4. Wind direction shear is not considered as this parameter is measured very infrequently (σ_{ys} in OCD is not contributing to total σ_y).

5. The height of the structure to which the stack is attached is assumed to be 15m. This parameter is necessary to calculate structure downwash (σ_{yo} and σ_{zo}) contributions to total σ_y and σ_z.

6. The value of A used in the OCD structure downwash algorithms was assumed to equal 2.0. This is based on an assumed height of the structure to which the stack is attached of 15m and an effective stack height of 30m (physical stack height plus momentum, not buoyancy plume rise). As A = 2.0, then only σ_z is modified for structure downwash effects.

The calculations involved in determining the reasonable worst-case overwater horizontal turbulence intensity value for OCD are presented below:

MPTER

$\sigma_y^2 = \sigma_{yt}^2 + \sigma_{yb}^2$

Distance (m)	σ_{yt}	σ_{yb}	σ_y
1000	33.23	21.43	39.54
2000	63.68	21.43	67.19
3000	91.92	21.43	94.39
4000	119.18	21.43	121.09
5000	145.67	21.43	147.24

$\sigma_z^2 = \sigma_{zt}^2 + \sigma_{zb}^2$

Distance (m)	σ_{zt}	σ_{zb}	σ_z	$\sigma_y\sigma_z$
1000	13.95	21.43	25.57	1011.04
2000	21.63	21.43	30.45	2045.94
3000	26.98	21.43	34.46	3252.68
4000	30.48	21.43	37.55	4546.93
5000	34.21	21.43	40.37	5944.08

OCD

$\sigma_y^2 = \sigma_{yt}^2 + \sigma_{yb}^2 + \sigma_{ys}^2 + \sigma_{yo}^2$

Distance (m)	σ_{yt}	σ_{yo}	σ_{ys}	σ_{yb}	σ_y
1000	**	0.	0.	23.72	**
2000	**	0.	0.	23.72	**
3000	**	0.	0.	23.72	**
4000	**	0.	0.	23.72	**
5000	**	0.	0.	23.72	**

** To be calculated later

$\sigma_z^2 = \sigma_{zt}^2 + \sigma_{zb}^2 + \sigma_{zo}^2$

Distance (m)	σ_{zt}	σ_{zo}	σ_{zb}	σ_z
1000	2.44	7.98	23.72	25.15
2000	3.47	7.98	23.72	25.27
3000	4.26	7.98	23.72	25.39
4000	4.93	7.98	23.72	25.51
5000	5.51	7.98	23.72	25.63

OCD σ_y and *IYW* calculations

Distance (m)	OCD $\sigma_y \sigma_z$		MPTER $\sigma_y \sigma_z$
1000	25.15 σ_y	=	1011.04
2000	25.27 σ_y	=	2045.94
3000	25.39 σ_y	=	3252.68
4000	25.51 σ_y	=	4546.93
5000	25.63 σ_y	=	5944.08

Distance (m)	OCD σ_y		$(\sigma_{yt}^2 + \sigma_{yb}^2)^{1/2}$
1000	40.20	=	$(\sigma_{yt}^2 + 562.5)^{1/2}$
2000	80.96	=	$(\sigma_{yt}^2 + 562.5)^{1/2}$
3000	128.11	=	$(\sigma_{yt}^2 + 562.5)^{1/2}$
4000	178.24	=	$(\sigma_{yt}^2 + 562.5)^{1/2}$
5000	231.92	=	$(\sigma_{yt}^2 + 562.5)^{1/2}$

Distance (m)	σ_{yt}^2		σ_{yb}^2		σ_y^2	σ_{yt}
1000	σ_{yt}^2	+	562.5	=	1616.04	32.46
2000	σ_{yt}^2	+	562.5	=	6554.42	77.41
3000	σ_{yt}^2	+	562.5	=	16412.17	125.90
4000	σ_{yt}^2	+	562.5	=	31769.50	176.66
5000	σ_{yt}^2	+	562.5	=	53786.88	230.70

$\sigma_{yt} = 32.46 = IYW * 1000 * S_y(x)$; $S_y(x) = 0.9535$
$\sigma_{yt} = 77.41 = IYW * 2000 * S_y(x)$; $S_y(x) = 0.9129$
$\sigma_{yt} = 125.90 = IYW * 3000 * S_y(x)$; $S_y(x) = 0.8771$
$\sigma_{yt} = 176.66 = IYW * 4000 * S_y(x)$; $S_y(x) = 0.8452$
$\sigma_{yt} = 230.70 = IYW * 5000 * S_y(x)$; $S_y(x) = 0.8165$

$IYW = 32.46/(1000 * 0.9535) = 0.034$
$IYW = 77.41/(2000 * 0.9129) = 0.042$
$IYW = 125.90/(3000 * 0.8771) = 0.048$
$IYW = 176.66/(4000 * 0.8452) = 0.052$
$IYW = 230.70/(5000 * 0.8165) = \underline{0.056}$

mean: $\underline{0.046}$

The mean value of *IYW* was calculated to be 0.046 for the five distances analyzed. The mean value of *IYW* was then "rounded" to 0.045 for implementation into the reasonable worst-case data set.

A few observations can be made on the matching of $\sigma_y\sigma_z$ products between MPTER and OCD:

1. As the source (virtual source) to receptor distance decreases, the value of *IYW* necessary to match $\sigma_y\sigma_z$ products decreases. This is due to the insensitivity of OCD σ_z values to distance, while the MPTER values of σ_z decrease significantly with decreasing distance (x).

2. Buoyancy is the dominant factor in OCD σ_z values at all distances; buoyancy is the dominant factor in MPTER σ_z values at distances of less than one kilometer.

3. In these exercises, *IYW* is equal to 0.045 only at a 2500m distance from source (virtual source) to receptor.

4. Considerably smaller values of *IYW* would be necessary to match $\sigma_y\sigma_z$ products between OCD and COMPLEX-II corrected for overwater dispersion (σ_z = 0.5 σ_z as in CPX2APCD).

5. Considerably smaller values of *IYW* would be necessary to match $\sigma_y\sigma_z$ products between OCD and MPTER if OCD σ_z calculations were based on P-G stability class F calculations.

6. Buoyancy contributions to total σ_y and σ_z are greater in OCD than MPTER.

7. For all distances analyzed, σ_y values calculated by OCD are greater than those calculated by MPTER; σ_z values calculated by OCD are less than those calculated by MPTER at all distances analyzed.

8. Matching $\sigma_y\sigma_z$ products between OCD and MPTER (or COMPLEX-II) does not mean a matching of calculated concentrations. For example, terrain interactions, inversion height plume penetration and plume rise are not handled identically between the two models.

The matching of $\sigma_y\sigma_z$ products was performed between MPTER (COMPLEX-II without overwater dispersion corrections) and OCD. In order to review the relative concentrations calculated by OCDCPM and CPX2APCD (COMPLEX-II with overwater dispersion corrections (σ_z = *0.5* σ_z)), modeling analyses were performed for eight emissions scenarios (four different source configurations and two pollutants for each configuration). For each of the following four scenarios, SO_x and NO_x emissions were analyzed:

a. Exxon NMT at SALM approximately 11,500 feet from shore
b. Exxon NMT at SALM approximately 5,500 feet from shore
c. Platform Harmony in normal position
d. Platform Harmony 5 km closer to shore than normal position.

These emissions scenarios are representative of typical project configurations offshore Santa Barbara County.

The current APCD reasonable worst-case meteorological data set was utilized as input to OCDCPM, with the exception that *IYW* values of 0.035, 0.040, 0.050 and 0.060 were considered as a sensitivity analysis. Extensive onshore receptor grids used in the Exxon ATC modeling were employed.

CPX2APCD was run with reasonable worst-case meteorology per the current APCD protocol and with actual pre-construction meteorological data collected by Exxon in Las Flores Canyon. For CPX2APCD, the largest modeled concentrations resulted from the use of the actual meteorology data set. The results of the 8 scenarios modeled are summarized below.

OCDCPM/CPX2APCD MODELING RESULT RATIOS

IYW	MIN	MEAN	MAX
0.035	0.66	0.91	1.25
0.040	0.62	0.81	1.11
0.050	0.50	0.66	0.91
0.060	0.41	0.57	0.77

These figures indicate that an *IYW* value of 0.045 would probably result in a mean ratio of OCDCPM/CPX2APCD modeled concentrations of approximately 0.73. An *IYW* value of 0.045 was not specifically modeled in these analyses.

3. Conclusions

An *IYW* value of approximately 0.045 was determined to result in a matching of $\sigma_y\sigma_z$ products between OCD and MPTER. The *IYW* value of 0.045 provided a match of $\sigma_y\sigma_z$ products for OCD P-G stability class G σ_z values and no overwater dispersion corrections to the MPTER dispersion values. The value of *IYW* would have been considerably smaller had the MPTER dispersion values been modified to account for overwater dispersion ($\sigma_z = 0.5\ \sigma_z$) or had OCD σ_z values been based on P-G stability class F calculations.

The mean ratio of OCDCPM/CPX2APCD modeled concentrations was approximately 0.73. The results of the OCDCPM and CPX2APCD modeling are consistent with the value of *IYW* necessary to match $\sigma_y\sigma_z$ products between OCD and MPTER. The mean ratio of 0.73 for OCDCPM/CPX2APCD modeled concentrations is likely due to the differences in terrain corrections between the two models, partial plume penetrations calculated by OCDCPM and somewhat different plume rise calculations between the two models.

The *IYW* value of 0.045 compares to P-G σ_y values as follows:

DISTANCE	OCD σ_y	P-G F σ_y	P-G E σ_y
1000	49.03	39.54	50.94
2000	85.52	67.19	95.70
3000	120.76	94.39	138.13
4000	153.97	121.09	179.06
5000	185.24	147.24	218.87
MEAN:	118.90	93.89	136.54

This indicates that the use of *IYW* = 0.045 is an emulation of P-G stability class E-F (somewhat closer to E).

The choice of *IYW* equal to 0.045 as a reasonable worst-case value must still include a safety factor to avoid model underprediction. Based on EPA concerns that the OCD model appears to underpredict by 10 to 20 percent and APCD concerns that OCD underpredicts by roughly 45 percent (different statistics were used to draw the separate conclusions), a multiplication factor of 1.2 was chosen to alleviate concerns that OCDCPM would significantly underpredict observed pollution concentrations. The use of a multiplier to alleviate APCD concerns was first suggested by the ARB.

4. References

Smith, T.B, W.D. Saunders and F.H. Shair (1983), "Analysis of Santa Barbara Oxidant Study," MRI FR-1900, Meteorological Research Inc., Altadena, CA 91001.

Turner, D.B. (1970), "Workbook on Atmospheric Dispersion Estimates," Environmental Protection Agency, Office of Air Programs, Publication No. AP-26.